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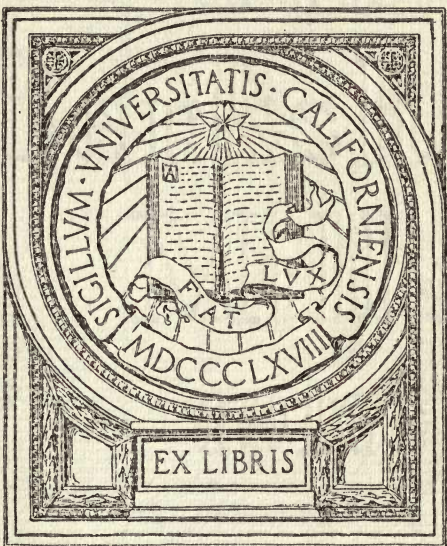
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IN MEMORIAM  
Prof. E. J. Wickson



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# Irrigation of the Sacramento Valley

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An Address at the Reception of the  
Congressional Irrigation Committee  
at Red Bluff, Cal., June 15, 1905

BY

J. B. LIPPINCOTT

Supervising Engineer  
Reclamation Service, United States Geological Survey

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# IRRIGATION

OF THE

# SACRAMENTO VALLEY

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ADDRESS OF

**J. B. LIPPINCOTT**

Supervising Engineer Reclamation Service, U. S. Geological Survey

At the Reception of the Congressional Irrigation Committee at  
Red Bluff, California, June 15, 1905.



Reprinted from the Red Bluff Daily News.

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E. J. Wickson

# Irrigation of the Sacramento Valley

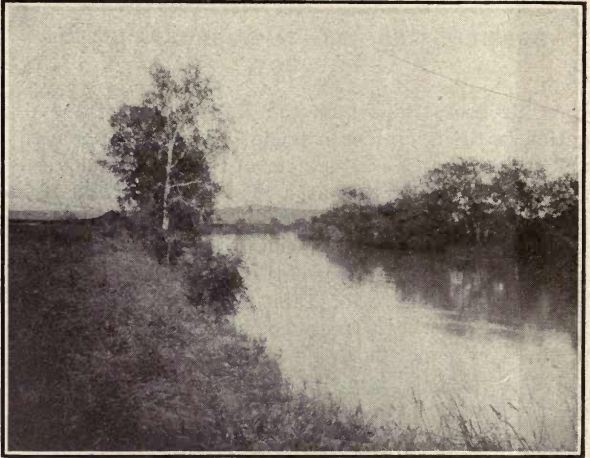
## POSSIBILITIES OF THE SACRAMENTO PROJECT.

A "Progress Report on the Hydrographic Investigation in the Sacramento Basin" has been completed and sent to the Chief Engineer of the U. S. Geological Survey, for publication as a Water Supply and Irrigation Paper.

Mr. S. G. Bennett, Engineer of the U. S. Reclamation Service, has prepared this report and is the engineer in charge of this project. A Board of Engineers has been freely consulted in reaching the preliminary conclusions herein presented.

This report is intended as a handbook on the questions of irrigation, drainage and storage of water in the Sacramento Basin. The first part of the report contains a general description of the Sacramento Valley; a brief statement in regard to climate, crops, markets and great opportunity for irrigation development; a short history of irrigation in California; the substance of the Reclamation Act; an outline of the organization of the Reclamation Service; a statement in regard to the co-operation between the State of California and the Departments of the Interior and Agriculture of the Federal Government in hydrographic, topographic, forestry and duty of water investigations. The Water and Forest Association, the Woodland and Willows Boards of Trade, as well as the State of California, have materially aided financially the Hydrographic Branch of the Geological Survey in the making of these investigations. The report also contains a brief description of the irrigation systems in the Sacramento Valley, and the

water-power development in the Sacramento Basin; and outline of the reports and work accomplished by the different departments of the State of California towards the solution of the problem of restraining the mining debris, and the reclamation of overflow lands



FEATHER RIVER AT HEAD OF BUTTE COUNTY IRRIGATION CANAL

of the Sacramento; a description of the hydrographic work accomplished by the U. S. Geological Survey, which includes maps and estimates of the cost of impounding works for proposed reservoirs.

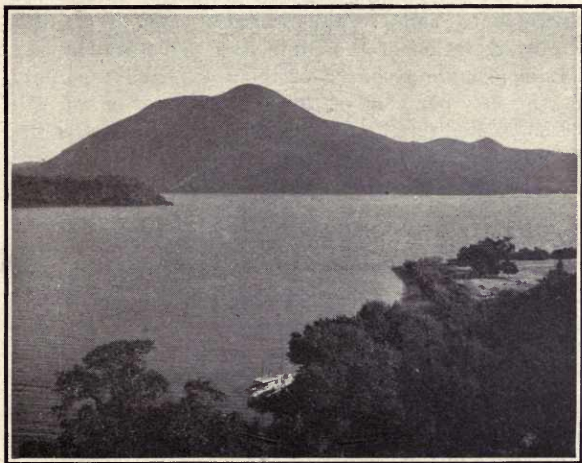
The report contains a review of Water Supply and Irrigation Papers Nos. 45 and 85 ("Water Storage on Cache Creek" and "Storage Reservoirs in Stony Creek, Cal.," respectively).

Part Two of the report contains all the hydrographic data available for the Sacramento River and tributaries, climatic details for Sacramento and Red Bluff, and Bibliography, thus bringing together in one volume an outline of all the work that has been accomplished to the present time in the Sacramento Valley by various organizations. It is believed that



it contains the information that is being sought by farmers, engineers and other inhabitants of the Sacramento Valley.

This is a progress report which will be followed by a second edition when the reconnaissance and surveys for reservoir sites have been extended to include the remaining tributaries of the Sacramento River, that is, the Feather, Yuba, Bear and American Rivers, and when the topographical surveys of the Sacramento Valley shall have been completed and sufficient information collected to formulate a plan to irrigate the entire valley.



CLEAR LAKE.

The study of the Sacramento Valley has been undertaken along the following broad lines: The hydrographic investigations have consisted of a complete exploration for reservoir sites throughout the drainage basin of the river. Where reservoirs have been found, their capacities have been determined by exact surveys and plans and estimates prepared for the construction of the dams. Gauging sta-

tions have been erected at or near the dam sites to determine the available water supply. This more detailed work has been extended throughout the western side of the basin, and also on the northern portion of the basin, including the Pit River.

The detail surveys are now being made, but are not yet complete for the eastern portion of the basin. Extensive storage reservoirs, however, are known to exist. Borings have not yet been made at the dam sites, and consequently the estimates are apt to be materially modified when this is done. The topographic branch of the Geological Survey has undertaken the mapping in detail of the entire floor of the Sacramento Valley. This work is being done with the co-operation of the State, the Geological Survey having complete charge of the work, and the State paying fifty per cent of the bill. These surveys will be completed for the portion of the valley west of the Sacramento River probably this year. With this data in hand, it will be possible to make preliminary locations of canal lines and to determine accurately irrigable areas.

The Bureau of Forestry of the Agricultural Department has taken up the complete study of the forest cover of the drainage basin, and has made extensive withdrawals of the remaining public lands for forest reserve. The preservation of these forests is of vital import in connection with the prevention of destructive flows, as well as the maintenance of the low water flow of the stream.

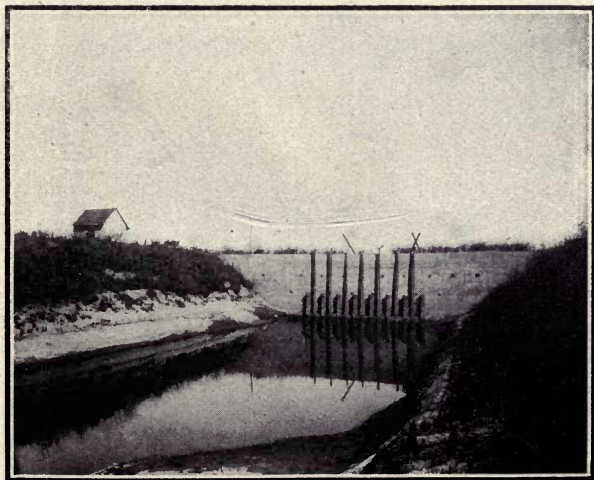
It is believed that the preservation of the forest will also be of great permanent value to the valley lands, as a continual source of lumber supply for that region.

The Bureau of Investigation of the Department of Agriculture has not, as yet, initiated extensive investigations as to the duty of water in the Sacramento Valley, but their work along this line in the future will undoubtedly be of great service in carrying out the project.

The State of California is lending financial aid to them in this work.

A Board of Army Engineers has been appointed to continue the study of the flood and overflow conditions of the Sacramento, together with the improvement of the navigable capacity of that stream. It is to be hoped that this work may be successfully carried out, as it will greatly enhance the general prosperity and proper development of this valley.

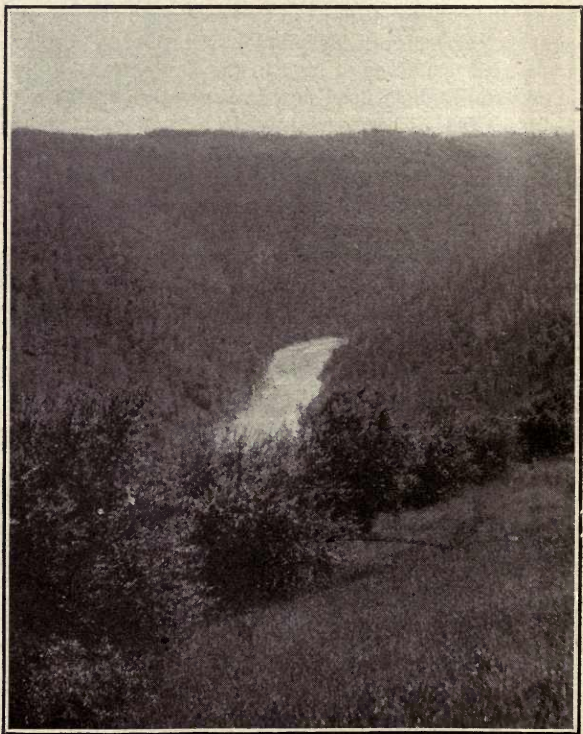
The program for this work does not in any manner interfere with or conflict with the work which is contemplated by the Reclamation Service. On the other hand, it is believed that the two programs can be, and will be, carried on in harmonious relation. There are over 2,000,000 acres of land in the Sacramento Valley above the highest flood flow in the valley, which may be irrigated. This, certainly, is a sufficient task to occupy the attention of the Reclamation Service for a number of years to come. If, upon the completion of this work, levees have been so constructed as to



HEADGATE, CENTRAL CANAL, ABOVE ST. JOHN.

permit of the irrigation and drainage of the lands which are now subject to overflow, it apparently will not be a difficult matter to extend the irrigation system on to these lands, because of their relatively low elevation.

The question of navigation should be carefully considered, and such a plan followed as will not lead to its destruction. It is believed that it will be feasible to divert water from the Sacramento River during the high stage of the river without injury to the navigation, and that during the low stages of the



NORTH FORK OF AMERICAN RIVER.

river, the supply for irrigation can be sustained from the storage reservoir in which flood waters have been impounded. The Sacramento River is technically a navigable stream under the jurisdiction of the Federal Government, and up to the present time, no diversions have been authorized therefrom which would affect the river when it falls to a stage two feet above low water mark. This probably implies that diversions for irrigation cannot be made subsequent to the 15th of July. The necessity for storage in connection with the maintenance of navigation, therefore, becomes apparent.

#### **WORK DONE BY THE IRRIGATION SURVEY.**

In 1889-90 reconnaissance and topographical surveys were made of a number of reservoir sites in Northern California by the U. S. Irrigation Survey. A short description of the sites located in the Sacramento Basin is given in the 12th and 13th Annual Reports of the Survey. At that time Clear Lake on Cache Creek, Summit Valley on the Yuba River in Nevada and Placer Counties, and Reservoir Sites known as Nos 43 and 44, in Alpine County, California, were surveyed.

#### **WORK DONE BY THE HYDROGRAPHIC BRANCH OF THE U. S. GEOLOGICAL SURVEY.**

A gauging station was established on the Sacramento River in April, 1895. The work of stream gauging has been extended until there are now fifteen gauging stations in the Sacramento Basin gauge, which measures 82 per cent of the flow from the basin. It has been the purpose of the Survey to establish and maintain these gauging stations at all points where reservoir sites are found, in order to determine the water supply available for storage. In 1900 a general plan was inaugurated to make a comprehensive study of the entire basin, with a view of treating the problem as a whole. A short description of the work thus far accomplished along this line will be

given, beginning at the southwest corner of the Sacramento Valley and describing in order the reservoirs in the various tributary basins.

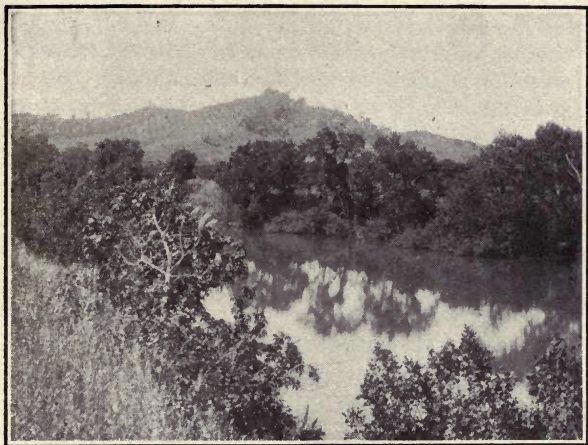
### PUTAH CREEK.

(Guenoc Reservoir):

Putah Creek is the most southerly of the Coast Range streams draining into the Sacramento Valley. Its basin was explored in July, 1903, for possible reservoir sites. Three were discovered. The Guenoc site was the most promising of these, and was surveyed in July and August, 1903. A second reservoir site has been surveyed in this basin during the present field season. It is located in Napa County. The dam site is 10 miles above Winters and only about 4 miles above the Sacramento Valley. Putah Creek has a drainage area of 600 square miles. The drainage area tributary to Guenoc reservoir site is estimated to be 91 square miles. This watershed is in the most elevated section of the Coast Range, and has several high peaks in the neighborhood. The precipitation in this watershed is heavy, and is almost entirely in the form of rain. The mean precipitation of the basin is probably not less than 50 inches, and the minimum not less than 30. The mean seasonal rainfall at the Helen quicksilver mine, in this basin, for the four years ending August, 1904, was 100.86 inches. On November 20, 1903, the precipitation was 5 inches. and for the 23½ hours ending at 4:30 p. m. of that day, the precipitation was 8½ inches. On account of the large amount and intensity of the rainfall, the run-off per square mile in this basin is very high.

### DISCUSSION REGARDING THE DAM.

Two types of dam have been estimated upon. The capacity of the reservoir for a 90-foot dam is 143,300 acre-feet and for a 100-foot dam, 188,000 acre-feet. It is believed that 80,000 acre-feet can be furnished from this reservoir annually. The estimated cost for



PUTAH CREEK, NEAR WINTERS.

installation of the works would be from \$4.03 to \$6.22, according to the type of dam built.

The work has not been completed on the maps of the survey of the reservoir on lower Putah Creek. It is estimated that the reservoir will hold from 75,000 to 100,000 acre-feet. It is believed that the run-off from the Putah Creek watershed will be sufficient, if these two reservoirs are constructed, to irrigate 80,000 acres of land.

#### **STORAGE OF WATER ON CACHE CREEK.**

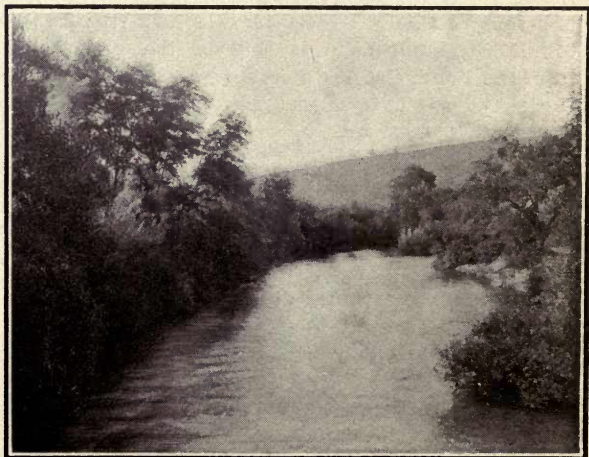
The drainage area of Cache Creek and its branches has been estimated at 1192 square miles. Five hundred square miles of this watershed are above the outlet of Clear Lake. This lake presents an excellent opportunity for the storage of 100,000 acre-feet of water at a small cost. This amount of water may be delivered without any serious interference with the lake levels under existing conditions. It would, however, be feasible to impound all the flood waters which are presented to Clear Lake by increas-

ing the height of dam at the outlet. Possibly the volume of water that could then be delivered from the reservoir might be double that named above. The advisability of such a procedure can only be determined as a result of future investigations.

The cost per acre-foot for this storage will depend upon the capacity of the outlet channel which shall be adopted. The cost per acre-foot with storage works and outlet channel of 8,000 second-feet capacity would be \$4.69; and with an outlet channel of 12,000 second-feet capacity, \$5.92.

### NORTH FORK OF CACHE CREEK.

Little Indian Valley is the only basin on the North Fork to be recommended as a reservoir site. It is five miles long and ranges from one-half to three-quarters of a mile in width. A reconnaissance survey of the valley was made in 1900 to determine its approximate storage capacity, which is estimated at 76,500 acre-feet. By comparison with the study of the run-off from Clear Lake, it is believed that the



CACHE CREEK, NEAR GUINDA.



basin tributary to this reservoir will furnish 50,000 acre-feet for irrigation purposes in the years of ordinary run-off. The estimated cost for the construction of the storage works at this point is \$453,000, which is at the rate of \$5.92 per acre-foot for the total storage capacity, or at the rates of \$9.06 per acre-foot of water available.

#### STORAGE RESERVOIRS, STONY CREEK BASIN.

This investigation was carried on in 1900 by the United States Geological Survey in co-operation with the California Water and Forest Association and the Willows Chamber of Commerce. The purpose of the work was, primarily, to determine what could be done towards increasing the area of lands irrigated in the basin of Stony Creek. Stony Creek has a drainage area of about 760 square miles. While the crest of the watershed does not exceed 6,700 feet in elevation, its proximity to the coast assures a substantial amount of rainfall. In the valley the precipitation is about 20 inches annually, while in the higher portions of the basin it probably reaches 40 inches. For the investigation of the storage possibilities of Stony Creek, nearly the entire drainage basin was visited. Stony Creek has a very peculiar topographic catchment area. The main stream, flowing northerly and parallel with the Coast Range, lies wholly in the sedimentary rock. At various points in the basin a conglomerate of more or less hardness is upturned in lines parallel with the axis of the mountain range, and has resisted erosion to a large extent. Wherever this ridge has been cross-cut by the various streams, dam and reservoir sites of more or less merit are found. This occurs in quite a number of instances, but only three of the reservoir sites have been surveyed. These are Briscoe Creek, East Park reservoir site and Mill Site reservoir site.

The Briscoe reservoir site has above it 50 square miles of good mountain drainage. Its storage capac-



STEAM SHOVEL, BUTTE COUNTY CANAL.

ity, with a 125-foot dam, would be 14,385 acre-feet, and the cost of building the storage works would be \$15.17 per acre-foot.

The East Park reservoir site is located on Little Stony Creek about two miles southeast of Stony Ford in Colusa County. From the survey of this reservoir site it is found that a 115-foot dam would impound 26,000 acre-feet of water at a cost for impounding of \$7.94 per foot.

Mill Site reservoir. This reservoir site is located at a point on Stony Creek near the Sacramento Valley. It has back of it over 500 square miles of drainage area, exclusive of Briscoe and Little Stony Creek. This is an important reservoir site. A dam at this point 95 feet above the bed of the stream would impound 43,735 acre-feet of water at a cost of \$13.32 per acre-foot for storage works.

### PIT RIVER BASIN.

Northeastern California is drained by the Pit River, which is one of the most important tributaries of the Sacramento River. The upper part of the basin is a series of high plateaus and abounds in old lake beds,

which offer remarkable opportunities for storing water. The gorges and canyons leading out of the valleys are usually quite narrow. Five reservoir sites were surveyed in this basin by the Reclamation Service in 1904. The most important of these is located on the main Pit River, a few miles below Bieber. It is known as the Big Valley reservoir site. The area of the watershed tributaries to the Big Valley reservoir is approximately 2,948 square miles. If it is found possible to drain Goose Lake and divert the run-off from this basin into Pitt River, the drainage area above Big Valley dam site will be approximately 4,200 square miles. The estimated run-off from the Pit River at Big Valley dam site for 1904, which was a year of large rainfall, was 1,245,422 acre-feet. The maximum discharge at this point was 18,320 second-feet. It is possible that 1,000,000 acre-feet could be supplied from this reservoir annually by diverting the flow now evaporated from the surface of Goose Lake, and giving the reservoir a capacity sufficiently large to store the surplus water in years when the discharge is above the average. The area exposed to evaporation from Big Valley



CANYON OF PIT RIVER.

reservoir, with a depth of 70 feet of water at the dam, is 83 square miles. The area of Goose Lake is 186 square miles. If the water that runs into this lake were stored in the Big Valley reservoir it would be sufficient to supply 260,000 acre-feet annually, and also all evaporation from the Big Valley reservoir. This is one of the largest reservoir sites ever surveyed in the arid West. With a depth of 100 feet of water at the dam, it has a capacity of approximately 3,200,000 acre-feet. It is estimated that 1,000,000 acre-feet could be impounded at this point at a cost of from \$2.01 to \$2.23 per acre-foot, according to the type of dam selected.

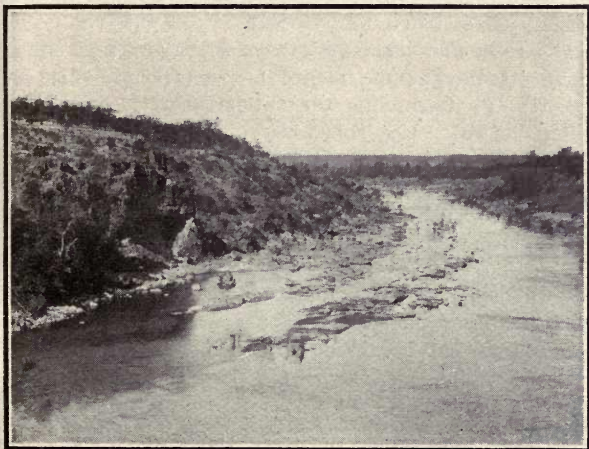
### IRON CANYON RESERVOIR SITE.

The Iron Canyon reservoir site, which was surveyed in 1903, is situated on the Sacramento River seven miles above Red Bluff, California. The estimated capacity of this site, with impounding works as designed, is 226,900 acre-feet. The cost of the storage works will be \$6.78 per acre-foot.

To summarize: By the construction of the Guenoc, Clear Lake, Little Indian Valley, Briscoe, East Park, Mill Site, Big Valley and Iron Canyon reservoirs, the amount of water available for irrigation from the Sacramento River and tributaries can be increased by 1,541,020 acre-feet, or sufficient water, if liberated during the months of July, August and September, to increase the flow of the Sacramento River more than 8,000 cubic feet per second. The low water flow at Red Bluff is about 3,000 second-feet. The cost for installation of these storage works as determined by preliminary estimates, would be \$5,800,035, or at the rate of \$3.76 per acre-foot for the construction of the works.

If these reservoirs were built under the Reclamation Act and paid for in ten equal payments the cost would be \$0.376 per acre-foot per annum. Diversion and drainage works needed to complete an irrigation system would materially add to this charge.

These figures must not at all be considered as final. They are merely given for purposes of comparison, and as indicative of the possible cost of these storage works. The ultimate cost of irrigation and drainage of lands, including charge for storage, seldom falls below \$20 per acre.



IRON CANYON OF THE SACRAMENTO.

These reservoirs can be so constructed that they will play an important part in controlling the crest of the flood waves of the Sacramento River, which has been so destructive of levees, crops and other property along the lower river. The controlling of the flood flow of Putah and Cache Creeks presents one of the greatest difficulties to be overcome in reclaiming the Yolo Basin. The flood flow of Putah and Cache Creeks may reach as much as 40,000 and 25,000 second-feet respectively, for short periods. If the Guenoc and Putah reservoirs were built, it is believed that the flood flow of Putah Creek could be reduced to one-half that amount.

The construction of the Clear Lake and Indian Valley reservoirs would, in a large measure, control

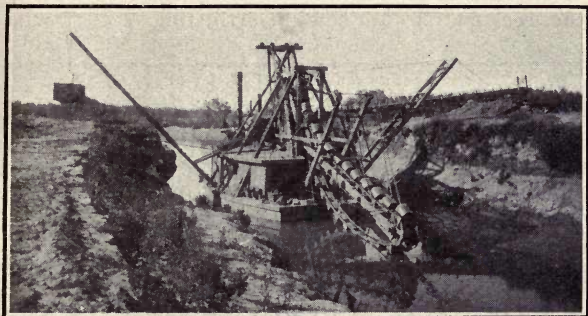
the flood flow of Cache Creek, if the outlets were regulated with that object in view. The flood wave of Stony Creek, which probably reaches 20,000 cubic feet per second, could be effectively controlled by the construction of Mill Site reservoir. Ordinarily reservoirs are allowed to fill with the first rains. Discharge records on Stony Creek show that the flow is many times more than the capacity of this reservoir. The reservoir could have been filled any year since the stream gauging record began after the first of April. By increasing the outlet capacity, and keeping the water low, this reservoir could be used as a regulator of the flood flow until the first of April. If the Iron Canyon reservoir were built with a large outlet capacity, all ordinary flood waves could be controlled. Even after the reservoir was full to the lip of the overflow weir, it would still have the effect of retarding the passage of the flood crest on account of the large surface afforded over which the water would have to be spread and stored before sufficient head could be gained on the overflow weir to pass the full flood flow.

The Big Valley reservoir, if built, could be made to entirely eliminate about 4,000 square miles of watershed tributary to the Sacramento River. These two reservoirs would give control of the flood flow from 35 per cent of the mountain area of the Sacramento Basin.

In spite of all precautions crevasses will sometimes occur during high water in levees of the best construction. They have occurred on the Mississippi levees, and will probably continue to do so on the Sacramento.

In a report of the State Engineer for 1881, Mr. William Ham Hall states: Such vast volumes of water as would overtop any line of levees which will ever be constructed in this valley will assuredly be brought down occasionally. No possible artificial embankments, and no possible development of the Sacramento River will provide waterway for the pre-

vention of the spread of waters of such floods as those of 1853, 1862, 1868, and perhaps others of which we have record. The Sacramento River now carries from eighty to ninety thousand cubic feet per second past Sacramento. We may make it carry 200,000 cubic feet, but we cannot make it carry 400,000 cubic feet, and I am of the opinion that the flood of 1862, or either of the others mentioned, perhaps, would have presented the last amount named in the lower river."



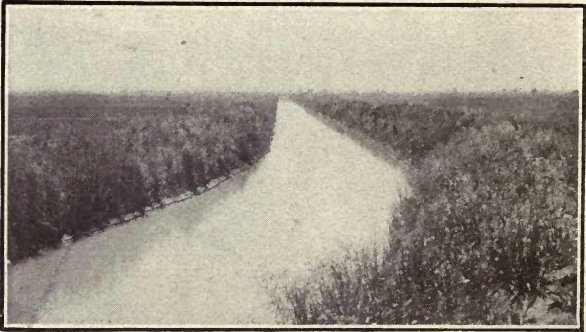
DREDGER ON CENTRAL CANAL, ST. JOHN.

On February 16 and 24, 1904, the Reclamation Service estimates that the total flood presented to the margin of the valley was over 500,000 second-feet. If a break should occur in the Sacramento levees after the improvements proposed by the Board of Army Engineers have been carried out and after the flood basins have been reclaimed and settled, the loss of property might be enormous. The property loss in one break might be greater than the entire first cost of the reservoirs. It is therefore most important to take every precaution to mitigate these floods, and it is believed that this reservoir construction would be justified on the basis of prevention of overflow alone.

Because of the intensity and the amount of precipitation in the upper Sacramento Basin, its flood waves are great but are of short duration. On this account,

the reservoirs will be especially useful in reducing and retarding the flood wave crests. It is believed that the additional expense of increasing the outlet capacity and making the reservoirs better adapted to serve the above purpose is justified and should be incurred.

It will be seen, then, how important it is that the irrigation of lands in the Sacramento Valley not subject to overflow, and the reclamation of the overflow lands be regarded as a co-ordinate work, and it is hoped that it will be so considered. The success of the reclamation projects in irrigating vast tracts

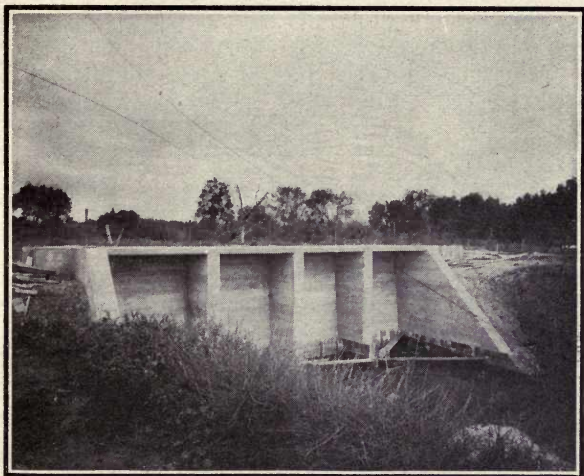


DAM ON BUTTE COUNTY IRRIGATION CANAL.

of land in the arid and semi-arid West, depends upon the co-operation of the farmer. The destiny of the Sacramento Valley is in the hands of the land owners. If the majority of these follow the short-sighted policy of holding the land in large tracts, and using it for raising grain, the soil will decrease in productiveness. The construction of numerous small canals will result in the same confusion and lack of system as had occurred with the independent levee construction upon which work over \$10,000,000 has been spent, and the results are chaotic. Little advance will be made either in increased population or wealth. On the other hand, if the land is subdivided and irri-



gated, the Sacramento Valley will ultimately sustain a population approaching that which is now supported by the entire State, and the increase in the value of land and taxable property will be many-fold. With increase in population will come many social advantages, electric railways and other transportation facilities, high schools, libraries, rural deliveries of mail. In fact, all the advantages of country and city life will be combined, as in the case of Fresno and many Southern California towns.

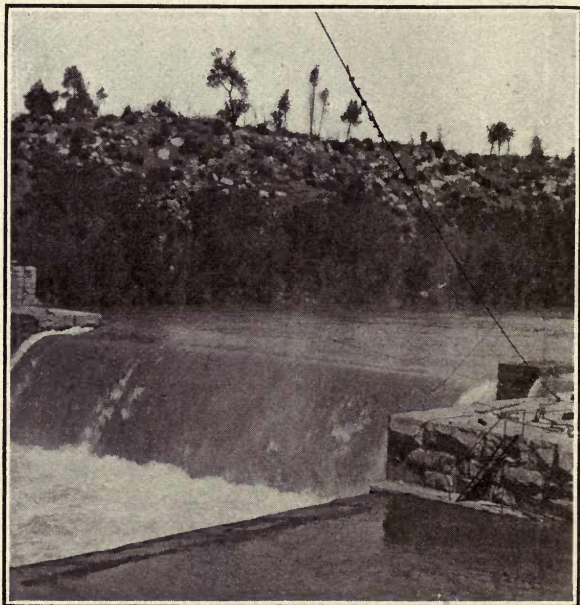


BUTTE COUNTY CANAL, NEAR BIGGS.

Until the topographic and soil surveys of the valley are completed, it will be difficult to even approximately give the location of the canals or the amount of land that is susceptible of irrigation. However, a general statement can be made in regard to this matter. The irrigable land may exceed 2,000,000 acres. It is estimated that 80,000 acres can be irrigated from Putah Creek, 80,000 acres from Cache Creek and 40,000 acres from Stony Creek. The water from these streams should be used to irrigate the

higher valley lands near the points where these streams leave the foothills. The remainder of the land on the west side of the valley would have to be irrigated by canals taking water from the Sacramento River. There are approximately 1,047,000 acres of land on the west side of the Sacramento Valley below Red Bluff, above the overflow line of the flood of 1904.

Upon the assumption that 77 per cent of this land is irrigable, and that the natural flow of the stream may be relied upon to furnish sufficient water for irrigation until the first of July, and that two acre-feet will irrigate an acre of land in the Sacramento Valley, the natural stream flow, together with the water impounded in the reservoirs thus far surveyed, would be sufficient to irrigate this west side land, and



FOLSOM DAM, AMERICAN RIVER.

probably furnish a surplus of half a million acre-feet to be applied for the irrigation of the northern part of the east half of the valley, as far south as Chico. It is believed that the flow from the streams draining the western slope of the Sierra Nevadas, supplemented by storage, would be sufficient to irrigate the



DIVERTING DAM OF NORTH FORK OF AMERICAN RIVER.

remainder of the east side land above the overflow line of the flood of 1904.

If the irrigation systems of the Sacramento Valley can be constructed by the Reclamation Service, the land owners have only to return the first cost of the works without interest, profit or taxes.

The engineering problems connected with the building of these storage works, together with the diversion and distribution of this water on the dry lands of the Sacramento Valley, are not difficult or uncertain, as is the case with the construction of levees for the prevention of overflow. The two real problems that are to be met before this work can be successfully carried out, are the provision of funds for the building of the work, and the agreement on the part of the land owners to accept this water under the terms of the Reclamation Act, if the Federal Government is to be the builder.

It will not be necessary to build the entire project at one time, and it is entirely feasible to build one after another of the various units involved in such a way as the results will be in harmony with the completed plant. Such work could be undertaken on Cache Creek or Stony Creek, or possibly by diversion at Red Bluff. It is important, however, that one general plan should be adhered to. It is quite possible that these gentlemen who are connected with this Congressional Committee on Irrigation may be of great assistance to you in helping to solve this financial problem.



FOLSOM DAM, AMERICAN RIVER.

With reference to the agreement on the part of the land owner to accept water for irrigation and to subdivide his lands, I do not have serious doubt. It has been a matter of pleasant surprise to find throughout arid America that difficulties of this nature can be overcome, both because of the profound confidence possessed by all in the ability of the Government to carry through its enterprises, and, second, because of the knowledge that the purpose of the Government is purely that of benefiting the country at large, and not for the bettering of any one locality or institution.

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